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A brief description of a project undertaken to modify and implement a BASIC version of Professor Jay W. Forrester's world simulation model WORLD 2 onto the Defense Intelligence Agency On-Line Computer System (DIAOLS).

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Defense Intelligence School

WORLD2 / DIAOLS -- A Project Report

by

CPT Michael B. Jeffress

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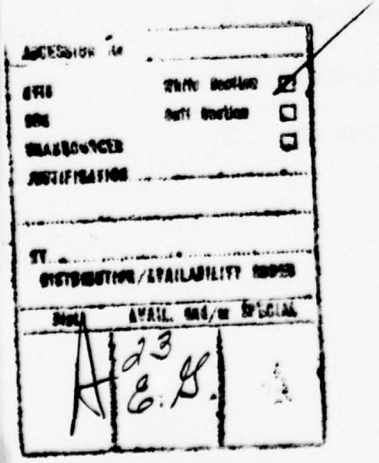

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LTC O.O. Wainwright

5 May 1978

WORLD2 / DIAOLS -- A Project Report

INTRODUCTION

The enclosed report is a brief description of a project undertaken to modify and implement a BASIC version of Professor Jay W. Forrester's world simulation model WORLD2 onto the Defense Intelligence Agency On-Line Computer System (DIAOLS). The original purpose of this project was to fill an existing void in the Defense Intelligence community. For most DIAOLS subscribers, particularly those outside the Washington area, no world simulation computer model has previously been available. The implementation of a BASIC model was originally seen only as an interim measure, pending the implementation of a DYNAMO compiler on DIAOLS (presently under test). As the model evolved through several modification stages, however, it became clear to me that, despite the eventual availability of DYNAMO, a BASIC version would still be necessary, desirable, and could serve a useful purpose on DIAOLS. Through wider availibility and dissemination, a BASIC WORLD2 could serve as a springboard for further inquiry into the field of System Dynamics by many intelligence professionals with little prior experience in the field. Whatever the eventual conclusions reached, the inevitable discussion and interchange resulting from this could only benefit the analytic community and improve the quality of the estimative intelligence product.

I. Background -- The Development of World Models

The relatively young field of system dynamics has its beginning in 1957, when a Ford Foundation grant was awarded to Professor Jay W. Forrester of the Massachusetts Institute of Technology for continued research and development of "industrial dynamics" -- a way to understand and design modern corporate policy[1]. From that project was developed a general viewpoint of the behavior of dynamic systems, particularly in relation to their feedback-loop structure. Since then, its application has been greatly expanded.

In 1968, the principles of "industrial dynamics" were further expanded to describe the general growth and stagnation characteristics of urban areas in Forrester's book, Urban Dynamics. In this work, Forrester extended the scope of his developed feedback-loop theory to describe the rise and decline of a city. With this application, the term "industrial dynamics" became a misnomer, and today the renamed theory of "system dynamics" is finding widespread application, not only in industry, but also in medical research, sociology, financial analysis, and organizational behavior, in addition to the subject of this project, global modeling.

In April, 1968, a group of thirty individuals from ten countries -- scientists, educators, economists, humanists, industrialists, and national and international civil servants --

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[1] Jay W. Forrester, World Dynamics (Cambridge, MA: Wright-Allen Press, Inc., 1971), p. IX.

gathered in the Accademia dei Lincei in Rome. They met at the instigation of Dr. Aurelio Peccei, an Italian industrial manager, economist, and man of vision, to discuss a subject of staggering scope -- the present and future predicament of man[2].

Thus was created the Club of Rome, an informal group that has been described as an "invisible college". Its purposes are to foster greater understanding of the interdependent global system; to bring that understanding to the attention of the world's decision-makers; and thus to promote new policies to best support that system[3].

The Club of Rome today remains an informal association with approximately seventy members of twenty-three nationalities. The membership of this association is limited, and will not exceed one hundred. None of its members hold public office, nor does the group owe any allegiance to any national, ideological, or political point of view. In general, however, all hold the conviction that the scope of the problems facing mankind are such that traditional institutions and processes are unable to deal with them. Therefore, new methodologies and techniques are required.

Early in their series of meetings, the members of the Club of Rome decided to initiate a very ambitious undertaking: the "Project on the Predicament of Mankind". The purpose of this immense project was to examine what they view as the central

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[2]Dennis L. Meadows and others, The Limits to Growth (New York: Universe Books, 1972), p. 9.

[3]Ibid.

problems facing mankind: poverty, environmental deterioration, loss of faith in institutions, uncontrolled urban sprawl, insecurity of employment, alienation of youth, rejection of traditional values, and inflation[4]. In their view, the predicament lies in the fact that, while man is fully capable of recognizing these various and diverse problems, he is unable to fathom the causes and interrelationships within the system, and is therefore unable to devise any suitable remedies.

Since a suitable methodology was not immediately found, the Club of Rome, meeting in Bern,Switzerland in late June 1970, invited Professor Forrester to come and discuss the possible applications of his system dynamics principles to "The Predicament of Mankind". This preliminary meeting led to the scheduling of a further meeting in July of the same year for ten days of detailed examination of this methodology to determine whether it was appropriate for this project. It was at this meeting, in July, that Professor Forrester and his group presented WORLD2 as a vehicle for discussion and study.

Described as a "preliminary effort" by Professor Forrester[5], WORLD2 was designed in a very short period of time by the MIT group to demonstrate the application of system dynamics techniques and principles to the problems of global modeling. Although elementary in comparison to the more sophisticated models to follow, WORLD2 was essentially the first attempt to use a

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[4]Ibid., p. 10.

[5]Forrester, op.cit., p. X.

computer model to simulate the behavior of the global system and its environment. While it has certain limitations, it is significant in that it is an effort to make explicit a specific world model so that it may be examined, modified, discussed, and refined to further enhance our understanding of the system's behavior. As such, WORLD2 was able to make a unique contribution to the field, and proved to be very controversial. Forrester's work with WORLD2 was published in World Dynamics (1971).

As a result of the July meeting in Cambridge, the Club of Rome decided to establish a one-year research program at MIT under the direction of Professor Dennis Meadows. This Phase One study, conducted with financial support from the Volkswagen Foundation[6], set out to examine, using systems dynamics, the five basic factors that determine and ultimately limit growth on earth. These factors -- population, agricultural production, natural resources, industrial production, and pollution -- were eventually integrated into a computer model that came to be called WORLD3. The report of this Phase One study group to the Club of Rome was published in Limits to Growth (1972). This book, which received much more widespread dissemination and discussion than World Dynamics, proved to be even more controversial, and eventually provoked published rebuttals, including Models of Doom (1973), a direct critique of both World Dynamics and Limits to Growth.

In essence, WORLD3 is simply an extended and refined

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[6]Meadows, op.cit., p. 11.

version of WORLD2. Its methodology, basic assumptions, and feedback-loop designs are very similar. WORLD3, however, contains many more variables and is capable of more sophisticated and disaggregated output. Its capabilities, limitations, and ultimate predictory conclusions about the future of the world system, then, are little different from WORLD2.

Following the pioneering work of Forrester and Meadows, the Club of Rome commissioned an impressive international group headed by Professor Mihajlo Mesarovic and Dr. Eduard Pestel to continue the project of global modeling. The Mesarovic - Pestel group, again financially supported by the Volkswagen Foundation, produced a much more sophisticated global simulation called the World System Computer Model, published in Mankind at the Turning Point (1974). While the WORLD2 and WORLD3 models had been deliberately limited to worldwide perspectives with no regional disaggregation, the Mesarovic - Pestel group was specifically charged with producing a regionalized world simulation model. This model, which is basically a new development of multilevel hierarchical systems theory, divides the world into ten interdependent and mutually interacting regions, and is capable of further breaking down the projected data into individual nations[7]. Currently in use at Case Western Reserve University, the Mesarovic - Pestel model is the most advanced application of system dynamics to global modeling yet devised.

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[7]Aurelio Peccei and Alexander King, "Commentary", Mankind at the Turning Point, Mesarovic and Pestel (N.Y.: E.P. Dutton and Co., Inc., 1974), p. 202.

II. WORLD2 -- A Basic Example

As previously discussed, the global simulation model WORLD2 is based on the systems dynamics theories developed at the Massachusetts Institute of Technology by Professor Jay W. Forrester. Since the purpose of this project is primarily to generate interest and integrate WORLD2 onto the DIALOS system, no attempt will be made to provide a thorough explanation of systems theory or a technical description of the design of WORLD2. That task was more than adequately handled by Professor Forrester in World Dynamics and is, in any case, beyond the scope of this paper. Rather, I will in this section provide a brief, non-technical orientation to the WORLD2 model with a discussion of its capabilities and primary limitations.

The basic philosophy behind the design of WORLD2 lies in what Professor Forrester calls "feedback loops". The feedback loop, as defined in World Dynamics, is "...the closed path that connects an action to its effects on the surrounding conditions, and those resulting conditions in turn come back as 'information' to influence further action"[8]. Feedback loops are applicable, according to Forrester, to all dynamic systems, from the simplest to the most complicated. Within each system, the principles of system structure dictate that two types of variables are found -- levels and rates. The levels are the system accumulators, and the rates are the inputs and outputs that cause the levels to change.

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[8] Forrester, op.cit., p. 17.

A level accumulates the net quantity that is determined by the flow rates into and out of the level. The system levels fully describe the condition of a system at any time[9]. One common example of a system level variable would be a bank savings account balance. The amount of the balance fully describes the condition of the account, and is in turn determined by the system rates -- rates of withdrawal, deposit, interest, and so on. In a global model, such as WORLD2, an analagous level variable would be population, whose value is determined at any time by the net quantity resulting from the input and output rates -- birth and death.

According to Forrester, all systems can be described by using only levels and rates[10]. These two types of variables are both necessary and sufficient to describe any system. In WORLD2, the global environment is represented by five level variables:

Population
Capital Investment
Natural Resources
Fraction of Capital in Agriculture
Pollution

In the system diagram of WORLD2 (Appendix A), these levels are represented by the rectangles. Each level is increased or decreased by the connecting rates of flow. The circles in the diagram are part of the rate descriptions that are independently determined and defined. Any closed path through the

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[9] Ibid., p. 18.

[10] Ibid.

diagram in the direction of the arrows is a feedback loop. Some loops are "positive-feedback" loops, generating growth, and some are "negative-feedback" loops, causing a system pressure for equilibrium.

The version of WORLD2 used for this project is essentially the same (in terms of capabilities) as Forrester's original. As described in the program instructions, WORLD2 can simultaneously track the relative development of 15 different variables (Appendix C(1)) over a variable period of time beginning in 1900. It is capable of producing either a graphical plot of any five of the variables or all can be listed numerically. As Forrester and Meadows point out, however, all numerical values are only approximate, and should be viewed relative to each other, not as objective measures of the exact variable value in the distant future.

As presently configured, WORLD2 contains 34 different variables (Appendix C(2)) that may be adjusted prior to model simulation. Most often, the variables to be modified would be the rate variables, initial level values, or those variables which control the graphical output. If no modification is desired, default values (identical to Forrester's original values) are provided. Following each simulation run, all changes to the original values may be retained, or default values restored, and the model restarted. Additionally, a new print/plot option may be selected.

For all their positive aspects, the WORLD models of Forrester and Meadows are not without their limitations. These

limitations, of course, were recognized early on, even by the Club of Rome:

> "One of the deliberate limitations of the previous research was its adoption of worldwide aggregations. This was a matter of choice, prompted by the objective of completing the project rapidly, providing at the same time an initial overall perspective of the trends and constraints inherent in the dynamics of the total system. We knew, of course, that the heterogeneity of the world, with its innumerable cultural and environmental differences, varying levels of development, and uneven distribution of natural resources, means the consequences of growth in different places is likewise heterogeneous. Thus the <u>average</u> curves and trends, as outlined in the first report, could not be adopted as a guide to detailed policy decisions in any particular country."[11]
>
> -- Aurelio Peccei
> Alexander King

From the beginning, then, it was obvious that WORLD2 could not be used as a blueprint for specific policy decisions in any particular world area. It is just too general, and cannot be made more specific. As Peccei stated, the results of WORLD2 are <u>averages</u> and should be analyzed as such. Thus, while the model may give general directions for world policy and emphasis, it is not an outline of specific remedies for the world's problems.

This shortcoming, which served as a motivation for further research projects, such as the Mesarovic - Pestel project, should not overshadow the positive contributions made by WORLD2. On the contrary, a general model such as WORLD2 can contribute much to our understanding of the behavior

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[11] Mihajlo Mesarovic and Eduard Pestel, op.cit., p. 202.

of the global system and its interactions. The researcher should always bear in mind this limitation, however, and not use a general model for a specific application.

In sum, WORLD2 is decptively simple, yet it is powerful beyond the scope of its equations, and only through careful analysis and experience is this simulation power and sensitivity revealed.

III. WORLD2 / DIAOLS -- Justification and Applications

Despite the many advances made since 1970 in the rapidly expanding field of sytems dynamics, the access to global simulation models for analytical research has been extremely limited. The reason for this is primarily that the DYNAMO language in which most of these models are written is not widely available. For those analysts and researchers whose only computer support is provided by the Defense Intelligence Agency On-Line System (DIAOLS), particularly those outside the Washington area, no global model of any type has been available, for DYNAMO is not currently available on DIAOLS. While this project was originally undertaken as an interim solution pending the eventual implementation of DYNAMO, it became obvious as the work progressed that a BASIC WORLD2 would have certain advantages that would tend to extend its useful life. Those advantages will be discussed in more detail later in this section.

Another hindrance to the project in the initial stages was the availability of a BASIC version of WORLD2. Quite by accident, this problem was solved from an unexpected source. In the January-February issue of Creative Computing magazine, a BASIC version of WORLD2, written by James L. Murphy of the University of California - San Bernadino, appeared. Upon close examination, this program was found to be functional and appeared to be suitable for modification and implementation onto the DIAOLS system. While this program, as found, was essentially a non-interactive, static translation of Forrester's model, it

could be modified and improved prior to implementation. Upon approval, this model was adopted as the basis for this project.

The first step in the development of WORLD2 / DIAOLS was to insure that the program as written would function on DIAOLS and accurately reproduce the results acheived by Forrester in his computer runs. After several minor programming chances to accomodate differences in the versions of BASIC used, it was found that Murphy's BASIC version of WORLD2 would indeed reproduce Forrester's results. Thus, the basic programming was sound. As originally configured, however, the BASIC WORLD2 model was very elementary -- it was not interactive with the user, it gave no instructions as to program operation, and made no provision for variable modification or repetitive simulation runs. In order to accomplish any of these tasks, the program had to be modified, and thus required at least some elementary knowledge of BASIC programming in order to make the most effective use of the model. In order to make the model more accessible to the non-technically oriented user, a more interactive system was desired - one in which the user needs little or no prior programming knowledge to operate. The program should lead the user step-by-step through the instruction and initialization phases, describing (if necessary) the various options in detail. In the end, the following characteristics were chosen as system goals:

-- user selection of:

* type of output - plot or list
* variables to be plotted

-- simple and complete execution instructions provided

-- simple user modification of selected variables

-- ability to re-run the model, retaining changes made, if desired

Following an extensive program revision which increased the program length by more than 60% (in lines), all of the above objectives were achieved, and the model results are still identical to Forrester's basic runs. In summary, the program changes initiated as a result of this project have made WORLD2 simpler and easier to use, and have given the prospective user more control over model manipulation and output, and, more importantly, require no programming knowledge to achieve full model operation.

Given, then, that WORLD2 / DIAOLS is implemented as modified, what are its possible applications, and what unique contributions justify its continued existence alongside a DYNAMO system? After only a short period of experience with the BASIC WORLD2, I believe it presents the following opportunities for use within the DIAOLS community:

(1) Within the Defense Intelligence School, WORLD2 / DIAOLS could, because of its simple operation, function very effectively as an introduction to Systems Dynamics in the NSIC, PGIC, and Analyst courses (for instance) of instruction. Its easy-to-use format would promote student interest, and avoid overly technical presentations to essentially non-technically oriented students.

(2) In the expanding electives program at the DIS, WORLD2 / DIAOLS could serve a deeper instructional purpose, providing immediate practical experience in systems dynamics in both dedicated systems courses and courses in BASIC programming without the need to learn a specialized programming language. Students could be exposed to systems analysis principles using the same BASIC language in which more general System Two application programs are written.

(3) For the Unified and Specified Commands and other non-Washington DIAOLS subscribers, WORLD2 / DIAOLS makes available a new toolfor macro-level global research. Despite its recognized limitations, WORLD2 does provide the user with a worldwide perspective on such problems as resource allocation, system interrelationships, and the possible effects of given policy courses of action on future global trends. In addition, the same advantages as in (2) above apply -- the model does not require the use or proficiency in a specialized programming language.

(4) Finally, WORLD2 / DIAOLS could possibly be seen as a complement to a future DYNAMO system, by serving as a lead-in to further research. Once one of the individuals in (1) - (3) above is given a painless, gentle, and non-technical introduction to systems theory by an easy-to-use BASIC model, the advantages and techniques of the admittedly more powerful DYNAMO language will be easily taught. If the individual wishes to pursue a more thorough and detailed research project, the basic tools of the trade will already be familiar, and they

will be required to learn only the new programming language, not the language and systems theory simultaneously.

IV. Summary -- The Outlook for the Future

As stated in the introduction, this project began with a very limited scope and objective -- simply to get WORLD2 "up and running" on DIAOLS. As this is written, however, it would seem that the contribution to be made by WORLD2 / DIAOLS is potentially of much greater significance. It is my belief that the field of Systems Dynamics represents a very powerful tool in the hands of man in his continuing quest to both define and shape his future life on Earth. As such, the continual development of the art and science of global modeling should be encouraged and nurtured by the Intelligence Community. To me, the connection between Systems Dynamics and Intelligence, particularly in the field of estimates, is both obvious and logical. In light of this, WORLD2 / DIAOLS can serve a useful function, both as an instructional aid and a research tool. For the estimator, it promotes a logical, systematic method of tracing the possible courses of the future. For the manager, it can assist in reshaping the traditional decision-making process. For all Intelligence officers, it can serve as a focus for discussion and inevitably improve the substantive intelligence product.

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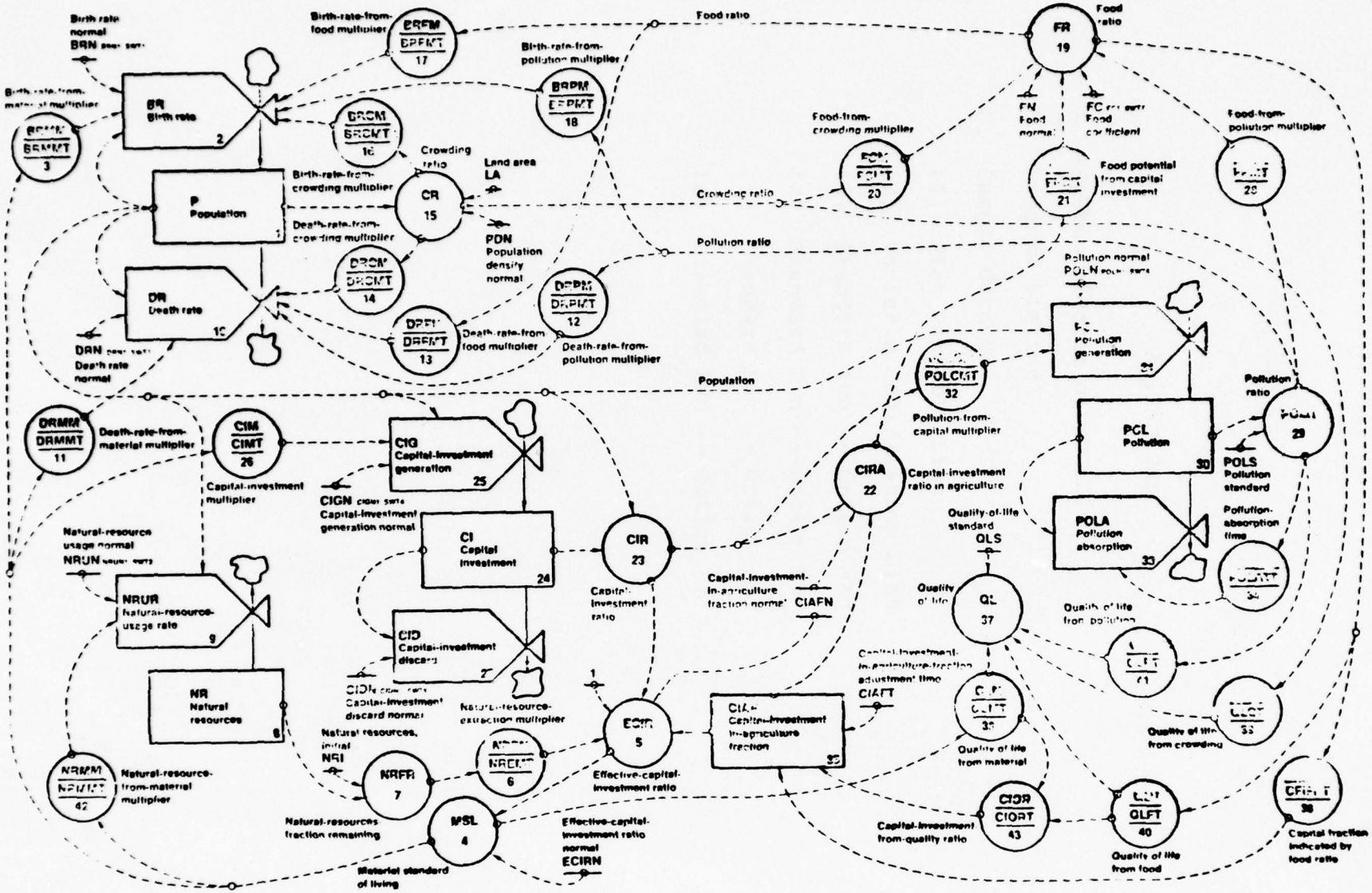


Figure 2-1 Complete diagram of the world model interrelating the five level variables — population, natural resources, capital investment, capital investment in agriculture fraction, and pollution

APPENDICES

A. System Diagram of WORLD2

B. Program Listing

C. Sample Output

   (1) Plot Variable List

   (2) Variable Modification List

   (3) Standard Run -- Option "A"

   (4) Standard Run -- Option "B"

   (5) Standard Run -- Option "C"

   (6) Standard Run -- Option "E"

```
100 REM ************************************************************
110 REM
120 REM                    W O R L D 2
130 REM
140 REM  A PROGRAM WRITTEN BY JAMES L. MURPHY AT CALIFORNIA STATE
150 REM  COLLEGE - SAN BERNARDINO BASED ON A MODEL BY JAY W. FORRESTER
160 REM  IN "WORLD DYNAMICS", WRIGHT-ALLEN PRESS, 1971, AND MODIFIED
170 REM  FOR USE AT THE DEFENSE INTELLIGENCE SCHOOL BY MICHAEL B.
180 REM  JEFFRESS IN APRIL 1978.
190 REM
200 REM ************************************************************
210 DIM B(15),C(5),D(21,10),E(34),P(51),U(15),Y(21),Z(15)
220 DIM A$(34),C$(34),V$(15),Y$(15),Z$(15)
230 FOR I= 1 TO 34
240 READ E(I)
250 NEXT I
260 FOR I= 1 TO 34
270 READ A$(I)\READ C$(I)
280 NEXT I
290 MAT D= ZER\MAT Y= ZER
300 FOR I= 0 TO 21
310 FOR J= 0 TO 10
320 READ D(I,J)
330 NEXT J
340 NEXT I
350 FOR I= 1 TO 15
360 READ V$(I)
370 NEXT I
380 FOR I= 1 TO 15
390 READ U(I)
400 NEXT I
410 DATA .026,.026,.4E9,.2,15,.3,.025,.025,1,1
420 DATA 1,1,135E6,.05,.05,5,5,900E9,1,1
430 DATA 1.65E9,26.5,1,.014,.014,.2E9,1,1,3.6E9,1900
440 DATA 2100,1970,1,20
450 DATA B1,BIRTH RATE NORMAL  -  BRN,B2,BIRTH RATE AFTER T3- BRN1
460 DATA C1,CAP.INVEST.INITIAL -  CII,C3,CAP.INV.AGRIC.FRAC.-CIAFI
470 DATA C5,CIAF ADJUST TIME  -CIAFT,C6,CIAF NORMAL        -CIAFN
480 DATA C7,CAP.INV.DISC.NORMAL- CIDN,C8,CIDN AFTER T3      -CIDN1
490 DATA F1,EFF.CAP.INV.RATIO -ECIRN,F3,FOOD NORMAL         -   FN
500 DATA F4,FOOD COEFFICIENT  -   FC,F5,FC AFTER T3         -  FC1
510 DATA F7,LAND AREA         -   LA,G1,CAP.INV.GEN.NORMAL - CIGN
520 DATA G2,CIGN AFTER T3     -CIGN1,L3,FREQUENCY OF PLOT  -PLOTF
530 DATA M3,FREQUENCY OF DATES -DATEF,N1,NAT.RES.INITIAL    -  NR1
540 DATA N3,NAT.RES.USAGE NORM.- NRUN,N4,NRUN AFTER T3      -NRUN1
550 DATA P1,POP.INITIAL       -   PI,P3,POP.DENSITY NORMAL -  PDN
560 DATA Q1,QUAL.LIFE STAN.   -  QLS,R1,DEATH RATE NORMAL  -  DRN
570 DATA R2,DRN AFTER T3      - DRN1,S1,POLLUTION INITIAL  - POLI
580 DATA S3,POLLUTION NORMAL  - POLN,S4,POLN AFTER T3      -POLN1
590 DATA S5,POLLUTION STANDARD - POLS,T1,INITIAL TIME      -TIME1
600 DATA T2,ENDING TIME       -TIME2,T3,SWITCHING TIME     -  SWT
610 DATA T4,CHANGE IN TIME    -DTIME,W2,PRINT FREQUENCY    -PRINT
620 REM BRCM FROM CR
630 DATA 1.05,1,.9,.7,.6,.55,0,0,0,0,0
640 REM DRCM FROM CR
650 DATA .9,1,1.2,1.5,1.9,3,0,0,0,0,0
660 REM FCM FROM CR
670 DATA 2.4,1,.6,.4,.3,.2,0,0,0,0,0
680 REM QLC FROM CR
690 DATA 2,1.3,1,.75,.55,.45,.38,.3,.25,.22,.2
700 REM FPCI FROM CIRA
```

```
720 REM POLCM FROM CIR
730 DATA .05,1,3,5.4,7.4,8,0,0,0,0,0
740 REM NREM FROM NRFR
750 DATA 0,.15,.5,.85,1,0,0,0,0,0,0
760 REM QLM FROM MSL
770 DATA .2,1,1.7,2.3,2.7,2.9,0,0,0,0,0
780 REM NRMM FROM MSL
790 DATA 0,1,1.8,2.4,2.9,3.3,3.6,3.8,3.9,3.95,4
800 REM CIM FROM MSL
810 DATA .1,1,1.8,2.4,2.8,3,0,0,0,0,0
820 REM DRMM FROM MSL
830 DATA 3,1.8,1,.8,.7,.6,.53,.5,.5,.5,.5
840 REM BRMM FROM MSL
850 DATA 1.2,1,.85,.75,.7,.7,0,0,0,0,0
860 REM FPM FROM POLR
870 DATA 1.02,.9,.65,.35,.2,.1,.05,0,0,0,0
880 REM DRPM FROM POLR
890 DATA .92,1.3,2,3.2,4.8,6.8,9.2,0,0,0,0
900 REM BRPM FROM POLR
910 DATA 1.02,.9,.7,.4,.25,.15,.1,0,0,0,0
920 REM QLP FROM POLR
930 DATA 1.04,.85,.6,.3,.15,.05,.02,0,0,0,0
940 REM BRFM FROM FR
950 DATA 0,1,1.6,1.9,2,0,0,0,0,0,0
960 REM DRFM FROM FR
970 DATA 30,3,2,1.4,1,.7,.6,.5,.5,0,0
980 REM CFIFR FROM FR
990 DATA 1,.6,.3,.15,.1,0,0,0,0,0,0
1000 REM QLF FROM FR
1010 DATA 0,1,1.8,2.4,2.7,0,0,0,0,0,0
1020 REM CIQR FROM QLM/QLF
1030 DATA .7,.8,1,1.5,2,0,0,0,0,0,0
1040 REM POLAT FROM POLR
1050 DATA .6,2.5,5,8,11.5,15.5,20,0,0,0,0
1060 DATA P2 - POPULATION,N2 - NATURAL RESOURCES,S7 - POLLUTION RATIO
1070 DATA Q2 - QUALITY OF LIFE,C2 - CAPITAL INVESTMENT
1080 DATA E8 - MATERIAL STAND. OF LIV.,N6 - NAT. RESOURCE USAGE
1090 DATA G4 - CAP. INVEST. RATIO,G5 - CAP. INVEST. RAT. AGRIC.
1100 DATA C4 - CAP. INVEST AG. FRAC.,S6 - POLLUTION GENERATED
1110 DATA F6 - FOOD RATIO,P2/R3 - LIFE EXPECTANCY,B3/P2 - BIRTH RATE
1120 DATA G3 - CROWDING RATIO
1130 DATA 8E9,2F12,40,2,2E10,4,20E9,4,4,1,40E9,2,100,.1,2
1140 IF T= 2 THEN 1790
1150 IF T= 3 THEN 1660
1160 PRINT "DO YOU DESIRE A PROGRAM DESCRIPTION OR INSTRUCTIONS IN THE"
1170 PRINT "USE OF 'WORLD2'?  TYPE IN YES OR NO—"
1180 INPUT X$
1190 IF X$= "NO" THEN 1660\IF X$= "No" THEN 1660\IF X$= "no" THEN 1660
1200 PRINT
1210 PRINT "WORLD2 IS A WORLD SIMULATION MODEL DEVELOPED BY JAY W. FORRESTER"
1220 PRINT "IN 'WORLD DYNAMICS' IN 1971.  IT IS CAPABLE OF ANALYZING THE"
1230 PRINT "RELATIVE DEVELOPMENT OF 15 DIFFERENT DYNAMIC VARIABLES OVER A"
1240 PRINT "VARIABLE PERIOD OF YEARS BEGINNING IN 1900.  WHILE THIS PROGRAM"
1250 PRINT "PROVIDES SUFFICIENT INFORMATION FOR OPERATION AND MANIPULATION"
1260 PRINT "OF THE MODEL, 'WORLD2' IS BEST USED IN CONJUNCTION WITH FORRES-"
1270 PRINT "TER'S 'WORLD DYNAMICS'.  IN THAT BOOK, FORRESTER EXPLAINS NOT"
1280 PRINT "ONLY THE GENERAL OPERATION OF THE MODEL, BUT ALSO GIVES MUCH MORE"
1290 PRINT "DETAILED DESCRIPTIONS OF THE VARIABLES USED."
1300 PRINT
1310 PRINT "                *** N O T E ***"
1320 PRINT
1330 PRINT "IT IS IMPORTANT TO REMEMBER WHEN USING 'WORLD2' THAT THE MODEL"
```

```
1380 PRINT "SHIPS ARE DESIRED, THE DATA TABLES LISTED IN THE PROGRAM IN"
1390 PRINT "LINES 620-1050 MUST BE MODIFIED."
1400 PRINT
1410 PRINT "THE VARIABLES WHICH MAY BE SELECTED FOR PLOTTING ARE:"
1420 PRINT
1430 PRINT "          A:          (1) P2 - POPULATION"
1440 PRINT "                      (2) N2 - NATURAL RESOURCES"
1450 PRINT "                      (3) S7 - POLLUTION RATIO"
1460 PRINT "                      (4) Q2 - QUALITY OF LIFE"
1470 PRINT "                      (5) C2 - CAPITAL INVESTMENT"
1480 PRINT
1490 PRINT "          B:          (6) F8 - MATERIAL STAND. OF LIV."
1500 PRINT "                      (7) N8 - NAT. RESOURCE USAGE"
1510 PRINT "                      (8) G4 - CAP. INVEST. RATIO"
1520 PRINT "                      (9) G5 - CAP. INVEST. RAT. AGRIC."
1530 PRINT "                     (10) C4 - CAP. INVEST. AG. FRAC."
1540 PRINT
1550 PRINT "          C:         (11) S6 - POLLUTION GENERATED"
1560 PRINT "                     (12) F6 - FOOD RATIO"
1570 PRINT "                     (13) P2/R3 - LIFE EXPECTANCY"
1580 PRINT "                     (14) B3/P2 - BIRTH RATE"
1590 PRINT "                     (15) G3 - CROWDING RATIO"
1600 PRINT
1610 PRINT "ANY GROUP OF VARIABLES MAY BE SELECTED BY GROUP CODE (A, B, OR C)"
1620 PRINT "OR 5 DIFFERENT VARIABLES MAY BE SELECTED BY SPECIFYING GROUP CODE"
1630 PRINT "'D' AND INDICATING VARIABLES BY NUMBER(1 - 15).  IN ADDITION,"
1640 PRINT "SELECTION OF OPTION 'E' WILL PROVIDE A NUMERICAL LISTING OF"
1650 PRINT "ALL 15 VARIABLES BY YEAR INTERVAL."
1660 PRINT
1670 PRINT "VARIABLE PLOT/PRINT OPTION DESIRED (A - E)";
1680 INPUT O$
1690 IF O$ <> "D" THEN 1700\GOTO 1710
1700 IF O$ <> "d" THEN 1740
1710 PRINT "VARIABLES DESIRED?"
1720 PRINT "TYPE IN #,#,#,#,#"
1730 INPUT A(1),A(2),A(3),A(4),A(5)
1740 IF T <> 0 THEN 1790
1750 PRINT\PRINT
1760 PRINT "'WORLD2' CONTAINS 34 VARIABLES WHICH MAY, IF DESIRED, BE"
1770 PRINT "INITIALIZED BY THE USER PRIOR TO MODEL SIMULATION.  IF NO"
1780 PRINT "MODIFICATION IS DESIRED, DEFAULT VALUES ARE PROVIDED."
1790 PRINT
1800 PRINT "DO YOU DESIRE A LISTING OF VARIABLES AVAILABLE FOR MODIFICATION"
1810 PRINT "WITH DESCRIPTIONS AND CURRENT VALUES?  TYPE IN YES OR NO—"
1820 INPUT T$
1830 IF T$= "NO" THEN 1990\IF T$= "No" THEN 1990\IF T$= "no" THEN 1990
1840 PRINT\PRINT
1850 PRINT "     VARIABLES AVAILABLE FOR MODIFICATION"
1860 PRINT
1870 PRINT " #       VARIABLE      VALUE          DESCRIPTION"
1880 PRINT
1890 FOR I= 1 TO 34
1900 IF I= 3 THEN 1950\IF I= 13 THEN 1950\IF I= 18 THEN 1950
1910 IF I= 21 THEN 1950\IF I= 26 THEN 1950\IF I= 29 THEN 1950
1920 IF I= 30 THEN 1970\IF I= 31 THEN 1970\IF I= 32 THEN 1970
1930 PRINT USING 2020,I,A$(I),E(I),C$(I)
1940 GOTO 1980
1950 PRINT USING 2030,I,A$(I),E(I),C$(I)
1960 GOTO 1980
1970 PRINT USING 2040,I,A$(I),E(I),C$(I)
1980 NEXT I
1990 PRINT\PRINT
```

```
2050 PRINT "FOR EACH SIMULATION, UP TO 34 VARIABLES MAY BE MODIFIED. "
2060 PRINT "DO YOU WISH TO MODIFY ANY VARIABLES?  TYPE IN YES OR NO—"
2070 INPUT S$
2080 IF S$= "NO" THEN 2240\IF S$= "No" THEN 2240\IF S$= "no" THEN 2240
2090 PRINT
2100 PRINT "ENTER VARIABLE LINE NUMBERS TO BE MODIFIED BELOW.  TO START"
2110 PRINT "MODEL SIMULATION, ENTER '0' (ZERO)."
2120 PRINT
2130 PRINT "VARIABLE LINE NUMBER TO BE MODIFIED (1 - 34)";
2140 INPUT I
2150 IF I= 0 THEN 2240
2160 PRINT
2170 K$= SST(C$(I),21,5)
2180 PRINT "CURRENT VALUE OF ";K$;" IS ";E(I)
2190 PRINT
2200 PRINT "DESIRED VALUE";
2210 INPUT E(I)
2220 PRINT
2230 GOTO 2130
2240 PRINT\PRINT\PRINT
2250 PRINT "********************** W O R L D 2 **********************"
2260 IF T= 1 THEN 2930
2270 Z$= "PNSQCMRIWAGFLBX"
2280 IF O$ <> "A" THEN 2290\GOTO 2300
2290 IF O$ <> "a" THEN 2310
2300 A9= 1
2310 IF O$ <> "B" THEN 2320\GOTO 2330
2320 IF O$ <> "b" THEN 2340
2330 A9= 2
2340 IF O$ <> "C" THEN 2350\GOTO 2360
2350 IF O$ <> "c" THEN 2370
2360 A9= 3
2370 IF O$ <> "D" THEN 2380\GOTO 2390
2380 IF O$ <> "d" THEN 2400
2390 A9= 4
2400 IF O$ <> "E" THEN 2410\GOTO 2420
2410 IF O$ <> "e" THEN 2430
2420 A9= 5
2430 Y$= Z$
2440 CHANGE Y$ TO Z
2450 ON A9 GOTO 2460,2500,2540,2580,2930
2460 FOR I= 1 TO 5
2470 C(I)= Z(I)
2480 NEXT I
2490 GOTO 2610
2500 FOR I= 1 TO 5
2510 C(I)= Z(I + 5)
2520 NEXT I
2530 GOTO 2610
2540 FOR I= 1 TO 5
2550 C(I)= Z(I + 10)
2560 NEXT I
2570 GOTO 2610
2580 FOR I= 1 TO 5
2590 C(I)= Z(A(I))
2600 NEXT I
2610 ON A9 GOTO 2620,2660,2700,2740
2620 FOR I= 1 TO 5
2630 B$(I)= V$(I)
2640 NEXT I
2650 GOTO 2770
2660 FOR I= 1 TO 5
2670 B$(I)= V$(I + 5)
```

```
2710 B$(I)= V$(I + 10)
2720 NEXT I
2730 GOTO 2770
2740 FOR I= 1 TO 5
2750 B$(I)= V$(A(I))
2760 NEXT I
2770 ON A9 GOTO 2780,2820,2860,2900
2780 FOR I= 1 TO 5
2790 W(I)= U(I)
2800 NEXT I
2810 GOTO 2930
2820 FOR I= 1 TO 5
2830 W(I)= U(I + 5)
2840 NEXT I
2850 GOTO 2930
2860 FOR I= 1 TO 5
2870 W(I)= U(I + 10)
2880 NEXT I
2890 GOTO 2930
2900 FOR I= 1 TO 5
2910 W(I)= U(A(I))
2920 NEXT I
2930 B1= E(1)
2940 B2= E(2)
2950 C1= E(3)
2960 C3= E(4)
2970 C5= E(5)
2980 C6= E(6)
2990 C7= E(7)
3000 C8= E(8)
3010 F1= E(9)
3020 F3= E(10)
3030 F4= E(11)
3040 F5= E(12)
3050 F7= E(13)
3060 G1= E(14)
3070 G2= E(15)
3080 L3= E(16)
3090 M3= E(17)
3100 N1= E(18)
3110 N3= E(19)
3120 N4= E(20)
3130 P1= E(21)
3140 P3= E(22)
3150 Q1= E(23)
3160 R1= E(24)
3170 R2= E(25)
3180 S1= E(26)
3190 S3= E(27)
3200 S4= E(28)
3210 S5= E(29)
3220 T1= E(30)
3230 T2= E(31)
3240 T3= E(32)
3250 T4= E(33)
3260 W2= E(34)
3270 T5= T1
3280 IF O$ <> "E" THEN 3290\W1= T5\GOTO 3310
3290 IF O$ <> "e" THEN 3300\W1= T5\GOTO 3310
3300 W1= T2 + 1
3310 C2= C1
3320 C4= C3
3330 M2= -1
```

```
3390 ON A9 GOTO 3400,3440,3480,3520,3610
3400 FOR I= 1 TO 5
3410 M$(I)= SST(Z$,I,1)
3420 NEXT I
3430 GOTO 3550
3440 FOR I= 1 TO 5
3450 M$(I)= SST(Z$,I + 5,1)
3460 NEXT I
3470 GOTO 3550
3480 FOR I= 1 TO 5
3490 M$(I)= SST(Z$,I + 10,1)
3500 NEXT I
3510 GOTO 3550
3520 FOR I= 1 TO 5
3530 M$(I)= SST(Z$,A(I),1)
3540 NEXT I
3550 FOR I= 1 TO 5
3560 PRINT M$(I);" REPRESENTS ";B$(I);"——SCALED TO ";W(I)
3570 NEXT I
3580 PRINT
3590 P$="      0.2       0.4       0.6       0.8       1.0 "
3600 PRINT "       0.0";P$
3610 IF T5 < T3 THEN 3690
3620 B1= B2
3630 R1= R2
3640 F4= F5
3650 S3= S4
3660 C7= C8
3670 G1= G2
3680 N3= N4
3690 G3= P2/(F7*P3)
3700 I= -1
3710 X= G3
3720 K= 5
3730 GOSUB 4780
3740 GOSUB 4780
3750 GOSUB 4780
3760 X= 2*G3
3770 K= 10
3780 GOSUB 4780
3790 G4= C2/P2
3800 G5= G4*C4/C6
3810 X= G5
3820 K= 6
3830 GOSUB 4780
3840 X= G4
3850 K= 5
3860 GOSUB 4780
3870 S6= P2*S3*Y(5)
3880 N5= N2/N1
3890 X= 4*N5
3900 K= 4
3910 GOSUB 4780
3920 F2= G4*(1-C4)*Y(6)/(1-C6)
3930 F8= F2/F1
3940 X= F8
3950 K= 5
3960 GOSUB 4780
3970 K= 10
3980 GOSUB 4780
3990 K= 5
4000 GOSUB 4780
4010 X= 2*F8
```

```
4050 K= 5
4060 GOSUB 4780
4070 N6= P2*N3*Y(8)
4080 G6= P2*Y(9)*G1
4090 G7= C2*C7
4100 S7= S2/S5
4110 X= S7/10
4120 K= 6
4130 GOSUB 4780
4140 GOSUB 4780
4150 GOSUB 4780
4160 GOSUB 4780
4170 F6= Y(4)*Y(2)*Y(12)*F4/F3
4180 X= F6
4190 K= 4
4200 GOSUB 4780
4210 X= 4*F6
4220 K= 8
4230 GOSUB 4780
4240 R3= P2*R1*Y(10)*Y(13)*Y(17)*Y(1)
4250 B3= P2*B1*Y(16)*Y(11)*Y(0)*Y(14)
4260 X= 2*F6
4270 K= 4
4280 GOSUB 4780
4290 X= F6
4300 GOSUB 4780
4310 X= 2*Y(7)/Y(19)
4320 GOSUB 4780
4330 X= S7/10
4340 K= 6
4350 GOSUB 4780
4360 S8= S2/Y(21)
4370 Q2= Q1*Y(7)*Y(3)*Y(19)*Y(15)
4380 IF T5 < W1 THEN 4420
4390 IF T5= W1 THEN 5360
4400 IF ((T5 - W1) - W2*INT((T5 - W1)/W2)) = 0 THEN 5430
4410 GOTO 4430
4420 GOSUB 4890
4430 P2= P2 + T4*(B3 - R3)
4440 N2= N2 - T4*N6
4450 S2= S2 + T4*(S6 - S8)
4460 IF S2 > 0 THEN 4480
4470 S2= 0
4480 C4= C4 + (T4/C5)*(Y(18)*Y(20) - C4)
4490 C2= C2 + T4*(G6 - G7)
4500 T5= T5 + T4
4510 IF T5 < (T2 + T4) THEN 3610
4520 PRINT\PRINT
4530 PRINT "********** W O R L D 2 **********"
4540 PRINT\PRINT
4550 PRINT "SIMULATION IS COMPLETED.  DO YOU WANT TO:"
4560 PRINT
4570 PRINT "          **STOP?                                    ...TYPE '0'"
4580 PRINT
4590 PRINT "          **MODIFY ADDITIONAL VARIABLES,"
4600 PRINT "            RETAIN ALL CHANGES MADE,                 ...TYPE '1'"
4610 PRINT "            AND RESTART THE MODEL?"
4620 PRINT
4630 PRINT "          **MODIFY ADDITIONAL VARIABLES,"
4640 PRINT "            RESET VARIABLES TO DEFAULT,              ...TYPE '2'"
4650 PRINT "            AND RESTART THE MODEL?"
4660 PRINT
4670 PRINT "          **SELECT DIFFERENT PRINT/PLOT"
```

```
4700 INPUT T
4710 IF T= 0 THEN 5490
4720 IF T= 1 THEN 1790
4730 RESTORE
4740 IF T= 2 THEN 210
4750 IF T= 3 THEN 210
4760 GOTO 5490
4770 REM **********TABLE INTERPOLATION ROUTINE**********
4780 I= I + 1
4790 IF X < 0 THEN 4810
4800 GOTO 4820
4810 X= 0
4820 J= INT(X) + 1
4830 IF X < K THEN 4860
4840 Y(I)= D(I,K)
4850 GOTO 4870
4860 Y(I)= D(I,J) + (X - J)*(D(I,J) - D(I,J - 1))
4870 RETURN
4880 REM **********PLOT ROUTINE**********
4890 B(1)= P2\B(2)= N2\B(3)= S7\B(4)= Q2\B(5)= C2
4900 B(6)= F8\B(7)= N6\B(8)= G4\B(9)= G5\ B(10)= C4
4910 B(11)= S6\B(12)= F6\B(13)= P2/R3\B(14)= R3/P2\B(15)= G3
4920 ON A9 GOTO 4930,4970,5010,5050
4930 FOR I= 1 TO 5
4940 V(I)= B(I)
4950 NEXT I
4960 GOTO 5080
4970 FOR I= 1 TO 5
4980 V(I)= B(I + 5)
4990 NEXT I
5000 GOTO 5080
5010 FOR I= 1 TO 5
5020 V(I)= B(I + 10)
5030 NEXT I
5040 GOTO 5080
5050 FOR I= 1 TO 5
5060 V(I)= B(A(I))
5070 NEXT I
5080 L6= 0
5090 L2= T5 - T1
5100 L4= L2 - INT (L2/L3)*L3
5110 IF L4◇0 THEN 5350
5120 MAT P= CON \ MAT P= (32)*P
5130 M2= M2 + 1
5140 IF (M2 - INT(M2/M3)*M3) ◇ 0 THEN 5180
5150 MAT P= CON
5160 MAT P= (45)*P
5170 L5= 1
5180 FOR L1= 1 TO 51 STEP 10 \ P(L1)= 124
5190 NEXT L1 \ FOR L1= 1 TO 5
5200 L4= INT(50*V(L1)/W(L1) + .5) + 1
5210 IF L4 > 51 THEN 5230
5220 GOTO 5240
5230 L4= 51
5240 IF L4 < 1 THEN 5260
5250 GOTO 5270
5260 L4= 1
5270 P(L4)= C(L1)
5280 NEXT L1
5290 P(0)= 51
5300 CHANGE P TO P$
5310 IF L6= 0 THEN 5340
5320 PRINT T5;" ";P$
```

```
5370 PRINT SPC(13);"CIAF"
5380 PRINT SPC(8);"POLR";SPC(11);"QL";SPC(12);"CR";SPC(12);"CIR";
5390 PRINT SPC(13);"CIRA"
5400 PRINT SPC(9);"MSL";SPC(11);"FR";SPC(10);"NRFR";SPC(11);"BR/P";
5410 PRINT SPC(9);"LIFE EXP"
5420 PRINT
5430 PRINT USING 5440,T5,P2,N2,C2,C4
5440:       ####       #.###          #.###^^^^       #.###^^^^       .######
5450 PRINT S7,Q2,G3,G4,G5
5460 PRINT F8,F6,N5,B3/P2,P2/R3
5470 PRINT
5480 GOTO 4430
5490 END
```

DO YOU DESIRE A PROGRAM DESCRIPTION OR INSTRUCTIONS IN THE USE OF 'WORLD2'? TYPE IN YES OR NO—
?
YES

WORLD2 IS A WORLD SIMULATION MODEL DEVELOPED BY JAY W. FORRESTER IN 'WORLD DYNAMICS' IN 1971. IT IS CAPABLE OF ANALYZING THE RELATIVE DEVELOPMENT OF 15 DIFFERENT DYNAMIC VARIABLES OVER A VARIABLE PERIOD OF YEARS BEGINNING IN 1900. WHILE THIS PROGRAM PROVIDES SUFFICIENT INFORMATION FOR OPERATION AND MANIPULATION OF THE MODEL, 'WORLD2' IS BEST USED IN CONJUNCTION WITH FORRESTER'S 'WORLD DYNAMICS'. IN THAT BOOK, FORRESTER EXPLAINS NOT ONLY THE GENERAL OPERATION OF THE MODEL, BUT ALSO GIVES MUCH MORE DETAILED DESCRIPTIONS OF THE VARIABLES USED.

*** N O T E ***

IT IS IMPORTANT TO REMEMBER WHEN USING 'WORLD2' THAT THE MODEL IS BASED ON SPECIFIC ASSUMPTIONS MADE BY FORRESTER AS TO THE RELATIONSHIPS BETWEEN THE VARIOUS COMPONENTS OF THE MODEL. THESE RELATIONSHIPS ARE NOT ADJUSTABLE BY THE USER DURING NORMAL PROGRAM EXECUTION. IF MODIFICATIONS TO THESE RELATIONSHIPS ARE DESIRED, THE DATA TABLES LISTED IN THE PROGRAM IN LINES 620-1050 MUST BE MODIFIED.

THE VARIABLES WHICH MAY BE SELECTED FOR PLOTTING ARE:

A:
(1) P2 - POPULATION
(2) N2 - NATURAL RESOURCES
(3) S7 - POLLUTION RATIO
(4) Q2 - QUALITY OF LIFE
(5) C2 - CAPITAL INVESTMENT

B:
(6) F5 - MATERIAL STAND. OF LIV.
(7) N6 - NAT. RESOURCE USAGE
(8) C4 - CAP. INVEST. RATIO
(9) C5 - CAP. INVEST. RAT. AGRIC.
(10) C4 - CAP. INVEST. AG. FRAC.

C:
(11) S6 - POLLUTION GENERATED
(12) F6 - FOOD RATIO
(13) P2/R3 - LIFE EXPECTANCY
(14) B3/P2 - BIRTH RATE
(15) G3 - CROWDING RATIO

ANY GROUP OF VARIABLES MAY BE SELECTED BY GROUP CODE (A, B, OR C) OR 5 DIFFERENT VARIABLES MAY BE SELECTED BY SPECIFYING GROUP CODE 'D' AND INDICATING VARIABLES BY NUMBER(1 - 15). IN ADDITION, SELECTION OF OPTION 'E' WILL PROVIDE A NUMERICAL LISTING OF ALL 15 VARIABLES BY YEAR INTERVAL.

VARIABLE PLOT/PRINT OPTION DESIRED (A - E) ?

'WORLD2' CONTAINS 34 VARIABLES WHICH MAY, IF DESIRED, BE INITIALIZED BY THE USER PRIOR TO MODEL SIMULATION. IF NO MODIFICATION IS DESIRED, DEFAULT VALUES ARE PROVIDED.

DO YOU DESIRE A LISTING OF VARIABLES AVAILABLE FOR MODIFICATION WITH DESCRIPTIONS AND CURRENT VALUES? TYPE IN YES OR NO—
?
YES

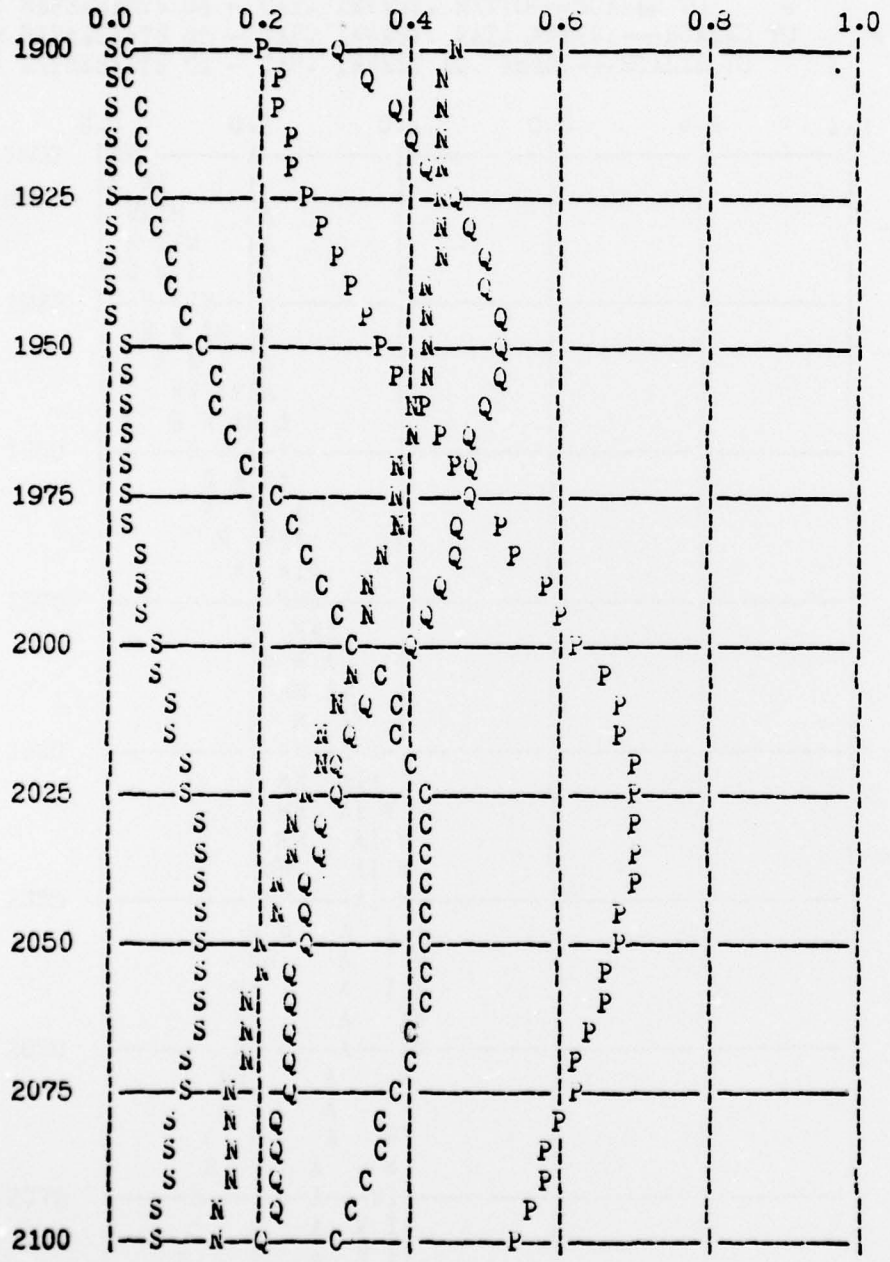
VARIABLES AVAILABLE FOR MODIFICATION

#	VARIABLE	VALUE	DESCRIPTION
1	B1	.026	BIRTH RATE NORMAL - BRN
2	B2	.026	BIRTH RATE AFTER T3- BRN1
3	C1	4.00e 08	CAP.INVEST.INITIAL - CII
4	C3	.200	CAP.INV.AGRIC.FRAC.-CIAFI
5	C5	15.000	CIAF ADJUST TIME -CIAFT
6	C6	.300	CIAF NORMAL -CIAFN
7	C7	.025	CAP.INV.DISC.NORMAL- CIDN
8	C8	.025	CIDN AFTER T3 -CIDN1
9	F1	1.000	EFF.CAP.INV.RATIO -ECIRN
10	F3	1.000	FOOD NORMAL - FN
11	F4	1.000	FOOD COEFFICIENT - FC
12	F5	1.000	FC AFTER T3 - FC1
13	F7	1.35e 08	LAND AREA - LA
14	G1	.050	CAP.INV.GEN.NORMAL - CIGN
15	G2	.050	CIGN AFTER T3 -CIGN1
16	L3	5.000	FREQUENCY OF PLOT -PLOTF
17	M3	5.000	FREQUENCY OF DATES -DATEF
18	N1	9.00e 11	NAT.RES.INITIAL - NRI
19	N3	1.000	NAT.RES.USAGE NORM.- NRUN
20	N4	1.000	NRUN AFTER T3 -NRUN1
21	P1	1.65e 09	POP.INITIAL - PI
22	P3	26.500	POP.DENSITY NORMAL - PDN
23	Q1	1.000	QUAL.LIFE STAN. - QLS
24	R1	.014	DEATH RATE NORMAL - DRN
25	R2	.014	DRN AFTER T3 - DRN1
26	S1	2.00e 08	POLLUTION INITIAL - POLI
27	S3	1.000	POLLUTION NORMAL - POLN
28	S4	1.000	POLN AFTER T3 -POLN1
29	S5	3.60e 09	POLLUTION STANDARD - POLS
30	T1	1900	INITIAL TIME -TIME1
31	T2	2100	ENDING TIME -TIME2
32	T3	1970	SWITCHING TIME - SWT
33	T4	1.000	CHANGE IN TIME -DTIME
34	W2	20.000	PRINT FREQUENCY -PRINT

FOR EACH SIMULATION, UP TO 34 VARIABLES MAY BE MODIFIED.
DO YOU WISH TO MODIFY ANY VARIABLES? TYPE IN YES OR NO—
?

********** W O R L D 2 **********

P REPRESENTS P2 - POPULATION——SCALED TO 8.00000e 09
N REPRESENTS N2 - NATURAL RESOURCES——SCALED TO 2.00000e 12
S REPRESENTS S7 - POLLUTION RATIO——SCALED TO 40
Q REPRESENTS Q2 - QUALITY OF LIFE——SCALED TO 2
C REPRESENTS C2 - CAPITAL INVESTMENT——SCALED TO 2.00000e 10

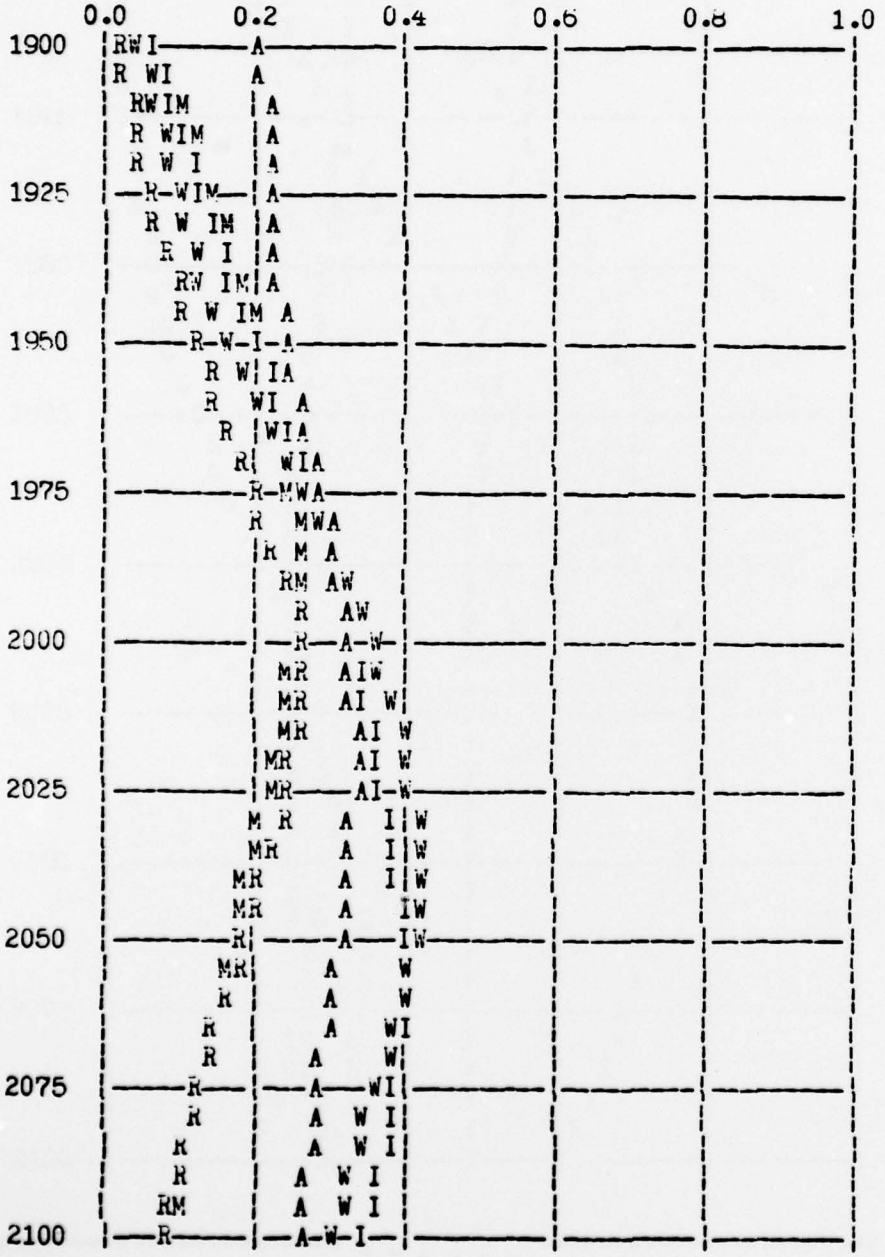


********** W O R L D 2 **********

NO

********** W O R L D 2 **********

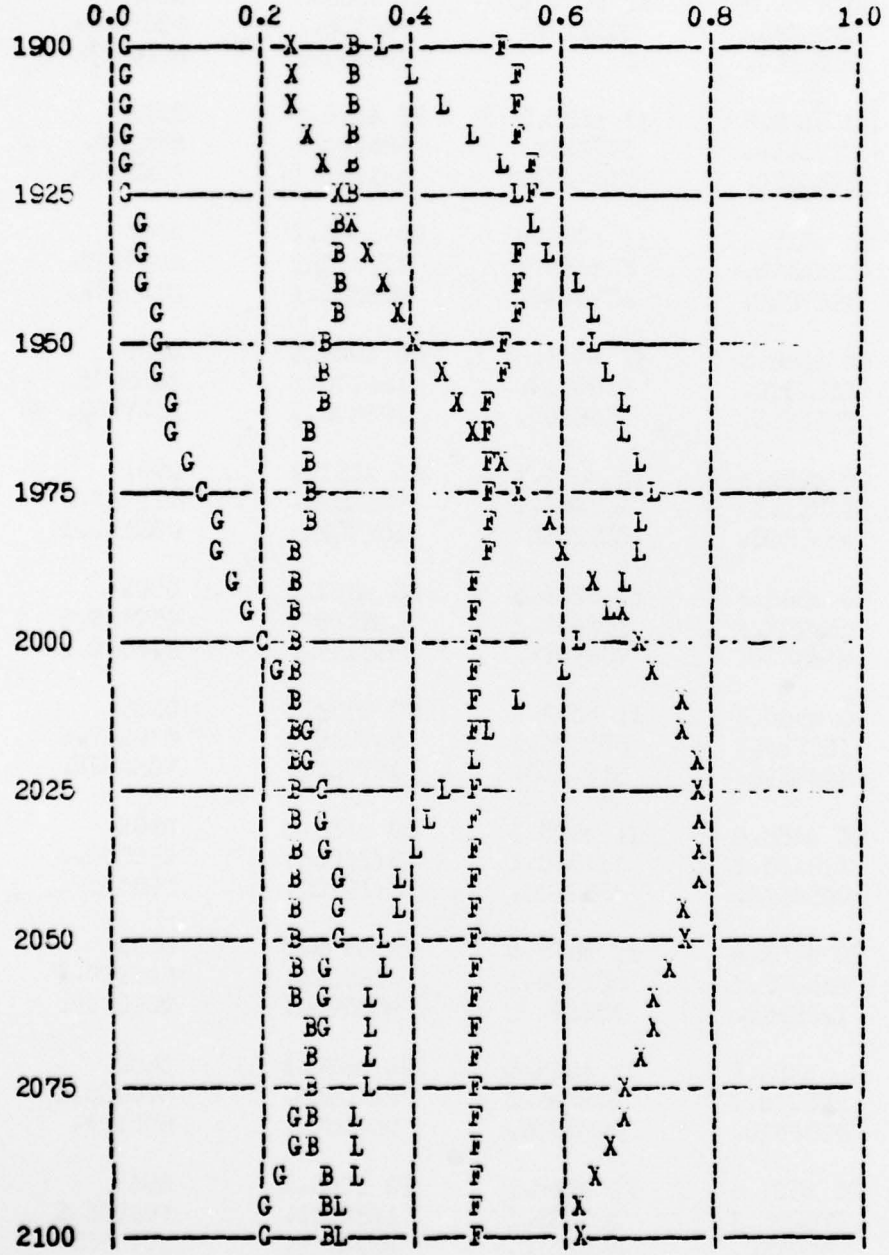
M REPRESENTS P8 - MATERIAL STAND. OF LIV.——SCALED TO 4
R REPRESENTS N6 - NAT. RESOURCE USAGE——SCALED TO 2.00000e 10
I REPRESENTS G4 - CAP. INVEST. RATIO——SCALED TO 4
W REPRESENTS G5 - CAP. INVEST. RAT. AGRIC.——SCALED TO 4
A REPRESENTS C4 - CAP. INVEST AG. FRAC.——SCALED TO 1



********** W O R L D 2 **********

********** W O R L D 2 **********

G REPRESENTS S6 - POLLUTION GENERATED——SCALED TO 4.00000e 10
F REPRESENTS F6 - FOOD RATIO——SCALED TO 2
L REPRESENTS P2/R3 - LIFE EXPECTANCY——SCALED TO 100
B REPRESENTS B3/P2 - BIRTH RATE——SCALED TO .1
X REPRESENTS G3 - CROWDING RATIO——SCALED TO 2



********** W O R L D 2 **********

NO

********** W O R L D 2 **********

DATE POLR MSL	POP QL FR	NR CR NRFR	CI CIR BR/P	CIAF CIRA LIFE EXP
1900	1.650e 09	9.000e 11	4.000e 08	.200000
.0555556	.611596	.4612159	.2424242	.1616162
.2770563	1.038609	1	.0318735	36.76589
1920	1.961e 09	8.863e 11	8.891e 08	.215210
.161558	.8590486	.5481915	.4533773	.3252377
.5036451	1.101284	.9847556	.0315628	51.24954
1940	2.533e 09	8.590e 11	1.713e 09	.229089
.3147404	1.011711	.7081523	.6761553	.5163334
.7243184	1.085269	.9544934	.0297325	61.02764
1960	3.280e 09	8.118e 11	2.986e 09	.258356
.5798151	1.007481	.9169015	.9102333	.7838822
.9077031	1.008694	.9020432	.0270773	67.32332
1980	4.131e 09	7.409e 11	4.669e 09	.295855
1.149196	.9380587	1.154632	1.13024	1.114625
1.016309	.987254	.8231733	.0253664	70.92362
2000	5.026e 09	6.469e 11	6.582e 09	.321481
2.252759	.7812843	1.404834	1.309638	1.403413
1.023446	.9664561	.7187237	.0238568	62.95345
2020	5.565e 09	5.443e 11	8.056e 09	.331693
3.742919	.6067765	1.555676	1.447501	1.601388
.8934307	.9407774	.6047766	.0230056	47.22732
2040	5.531e 09	4.518e 11	8.584e 09	.322477
4.908822	.5301516	1.546111	1.551911	1.668166
.7551683	.9519116	.5019635	.0235889	38.82763
2060	5.206e 09	3.776e 11	8.223e 09	.299768
4.772643	.4903811	1.455136	1.579654	1.578435
.6120907	.9696568	.41954	.0249641	34.98063
2080	4.823e 09	3.228e 11	7.285e 09	.277566
3.525478	.4520749	1.348209	1.510371	1.397426
.471008	.9752937	.3586894	.0264604	32.60054
2100	4.393e 09	2.845e 11	6.106e 09	.260927
2.307494	.4179501	1.228091	1.389673	1.208675
.3558706	.9770464	.3161026	.0278062	30.47183

********** W O R L D 2 **********